WHAT IS CLAIMED IS:

1. A method of forming a magnetic nanostructure comprising:

depositing a magnetic nanostructure precursor on a substrate from a nanoscopic tip; and

converting the precursor to form the magnetic nanostructure on the substrate.

2. The method according to claim 1, wherein the magnetic nanostructure precursor is a ferromagnetic nanostructure precursor.

3. The method according to claim 1, wherein the magnetic nanostructure precursor is a hard magnetic nanostructure precursor.

4. The method according to claim 1, wherein the magnetic nanostructure precursor is a semi-hard magnetic nanostructure precursor.

5. The method according to claim 1, wherein the magnetic nanostructure precursor is a soft magnetic nanostructure precursor.

6. The method according to claim 1, wherein the depositing step is carried out with use of a solid tip having the magnetic nanostructure precursor at the end of the tip.

7. The method according to claim 1, wherein the depositing step is carried out with use of a scanning probe microscope tip.

8. The method according to claim 1, wherein the depositing step is carried out with use of a hollow tip.

9. The method according to claim 1, wherein the depositing step is carried out with use of a sol-gel precursor.

10. The method according to claim 1, wherein the nanostructure has a size dimension other than height of about one micron or less.

11. The method according to claim 1, wherein the nanostructure has a size dimension other than height of about 100 nm or less, and wherein the conversion step comprises heating.

12. The method according to claim 1, wherein the depositing step is carried out with use of a solid tip having the hard magnet nanostructure precursor at the end of the tip and with use of a sol-gel precursor, and wherein the conversion step comprises heating.

13. The method according to claim 1, wherein the depositing step is carried out with use of an atomic force microscope tip, wherein the depositing step is carried out with use of a sol-gel precursor, wherein the conversion step comprises heating, and wherein the nanostructure has a size dimension other than height of about 100 nm or less.

14. A method of forming a hard magnet nanostructure comprising:

depositing a hard magnet nanostructure precursor on a substrate from a tip; and

converting the precursor to form the hard magnet nanostructure on the substrate.

15. The method according to claim 14, wherein the depositing step is carried out with use of a solid tip having the hard magnet nanostructure precursor at the end of the tip.

16. The method according to claim 14, wherein the depositing step is carried out with use of a scanning probe microscope tip.

17. The method according to claim 14, wherein the depositing step is carried out with use of a hollow tip.

18. The method according to claim 14, wherein the depositing step is carried out with use of a sol-gel precursor.

19. The method according to claim 14, wherein the nanostructure has a size dimension other than height of about one micron or less.

20. The method according to claim 14, wherein the nanostructure has a size dimension other than height of about 100 nm or less.

21. The method according to claim 14, wherein the conversion step comprises heating.

22. The method according to claim 14, wherein the depositing step is carried out with use of a solid tip having the hard magnet nanostructure precursor at the end of the tip, wherein the depositing step is carried out with use of a sol-gel precursor, and wherein the conversion step comprises heating.

23. The method according to claim 14, wherein the depositing step is carried out with use of an atomic force microscope tip, wherein the depositing step is carried out with use of a sol-gel precursor, wherein the conversion step comprises heating, and wherein the nanostructure has a size dimension other than height of about 100 nm or less.

24. A method of forming a soft magnet nanostructure comprising:

depositing a soft magnet nanostructure precursor on a substrate from a tip; and

converting the precursor to form the soft magnet nanostructure on the substrate.

25. The method according to claim 24, wherein the depositing step is carried out with use of a solid tip having the soft magnet nanostructure precursor at the end of the tip.

26. The method according to claim 24, wherein the depositing step is carried out with use of a scanning probe microscope tip.

27. The method according to claim 24, wherein the depositing step is carried out with use of a sol-gel precursor.

28. The method according to claim 24, wherein the nanostructure has a size dimension other than height of about 100 nm or less, and wherein the conversion step comprises heating.

29. The method according to claim 24, wherein the depositing step is carried out with use of a solid tip having soft magnetic ferrite nanostructure precursor at the end of the tip, wherein the depositing step is carried out with use of a sol-gel precursor, and wherein the conversion step comprises heating.

30. The method according to claim 24, wherein the depositing step is carried out with use of an atomic force microscope tip, wherein the depositing step is carried out with use of a sol-gel precursor, wherein the conversion step comprises heating, and wherein the nanostructure has a size dimension other than height of about 100 nm or less.

31. A method of forming a sol gel magnetic nanostructure comprising:

depositing a sol gel magnetic nanostructure precursor on a substrate from a tip; and

converting the precursor to form the sol-gel magnetic nanostructure on the substrate.

32. The method according to claim 31, wherein the depositing step is carried out with use of a solid tip having the hard magnetic nanostructure precursor at the end of the tip.

33. The method according to claim 31, wherein the depositing step is carried out with use of a solid tip having the soft magnetic nanostructure precursor at the end of the tip.

34. The method according to claim 31, wherein the depositing step is carried out with use of a scanning probe microscope tip.

35. The method according to claim 31, wherein the nanostructure has a size dimension other than height of about one micron or less.

36. The method according to claim 31, wherein the nanostructure has a size dimension other than height of about 100 nm or less.

37. The method according to claim 31, wherein the conversion step comprises heating.

38. The method according to claim 31, wherein the depositing step is carried out with use of a solid tip having the hard magnet nanostructure precursor at the end of the tip, wherein the nanostructure has a size dimension other than height of about 1,000 nm or less, and wherein the conversion step comprises heating.

39. The method according to claim 31, wherein the depositing step is carried out with use of an atomic force microscope tip, wherein the conversion step comprises heating, and wherein the nanostructure has a size dimension other than height of about 100 nm or less.

40. A method of forming an array of magnetic nanostructures comprising:

depositing one or more magnetic nanostructure sol-gel precursor on a substrate to form a plurality of nanostructures of precursors; and

converting the nanostructures to form the array of magnetic nanostructures.

41. The method according to claim 40, wherein the depositing step is carried out with use of a solid tip having the magnetic nanostructure sol gel precursor at the end of the tip.

42. The method according to claim 40, wherein the depositing step is carried out with use of an atomic force microscope tip.

43. The method according to claim 40, wherein the depositing step is carried out with use of a plurality of tips.

44. The method according to claim 40, wherein the nanostructure has a size dimension other than height of about one micron or less.

45. The method according to claim 40, wherein the nanostructure has a size dimension other than height of about 100 nm or less.

46. The method according to claim 40, wherein the conversion step comprises heating.

47. The method according to claim 40, wherein the depositing step is carried out with use of a solid tip having the hard magnet nanostructure precursor at the end of the tip,

wherein the depositing step is carried out with use of a sol-gel precursor consisting essentially of metallic precursors, and wherein the conversion step comprises heating.

48. The method according to claim 40, wherein the depositing step is carried out with use of an atomic force microscope tip, wherein the conversion step comprises heating, and wherein the nanostructure has a size dimension other than height of about 100 nm or less.

49. A method of forming a ferromagnetic nanostructure comprising:

depositing a ferromagnetic nanostructure precursor on a substrate; and

converting the precursor to form the ferromagnetic nanostructure on the substrate, wherein the precursor comprises a solvent based patterning ink consisting essentially of magnetic precursor and solvent in sol state.

50. The method according to claim 49, wherein the depositing step is carried out with use of a solid tip having the nanostructure precursor at the end of the tip.

51. The method according to claim 49, wherein the depositing step is carried out with use of an atomic force microscope tip.

52. The method according to claim 49, wherein the depositing step is carried out with use of a sol-gel precursor.

53. The method according to claim 49, wherein the nanostructure has a size dimension other than height of about 100 nm or less.

54. The method according to claim 49, wherein the conversion step comprises heating, including a preheating step and an annealing step, and the ferromagnetic nanostructure comprises barium ferrite.

55. The method according to claim 49, wherein the depositing step is carried out with use of a solid tip having the nanostructure precursor at the end of the tip, wherein the depositing step is carried out with use of a sol-gel precursor, wherein the ferromagnet is a hard ferromagnet, and wherein the conversion step comprises heating.

56. The method according to claim 49, wherein the depositing step is carried out with use of an atomic force microscope tip, wherein the depositing step is carried out with use of a sol-gel precursor, wherein the conversion step comprises heating, and wherein the nanostructure has a size dimension other than height of about one micron or less.

57. A method of nanolithography comprising:

providing a substrate,

providing a nanoscopic tip having an inking composition thereon, wherein the inking composition comprises at least one magnetic material precursor;

transferring the inking composition from the nanoscopic tip to the substrate to form a deposit on the substrate comprising at least one magnetic material precursor.

58. The method according to claim 57, wherein the converting step comprises heating the precursor to form the magnetic material.

59. The method according to claim 57, wherein the nanoscopic tip is a scanning probe microscopic tip.

60. The method according to claim 57, wherein the nanoscopic tip is an atomic force microscopic tip.

61. The method according to claim 57, wherein the inking composition is a sol-gel precursor.

62. The method according to claim 57, wherein the deposit has as least one lateral dimension which is about 1,000 nm or less.

63. The method according to claim 57, wherein the magnetic material is a hard magnetic material.

64. The method according to claim 57, wherein the magnetic material is a soft magnetic material.

65. A method of nanolithography comprising:

positioning a scanning probe microscopic tip having a magnetic reactive ink composition thereon relative to a substrate so that the reactive ink composition is transferred from the nanoscopic tip to the substrate to form a deposit on the substrate, wherein the reactive ink is a sol-gel precursor capable of undergoing a sol-gel reaction.

66. The method according to claim 65, further comprising the step of heating the deposit to substantially complete the sol gel reaction.

67. The method according to claim 65, wherein the tip is an atomic force microscopic tip.

68. The method according to claim 65, wherein the deposit is a hard magnetic deposit.

69. The method according to claim 65, wherein the deposit is a soft magnetic deposit.

70. A method of nanolithography comprising patterning a nanoscopic deposit comprising a magnetic solid state material precursor on a substrate, and converting the solid state material precursor to the magnetic solid state material.

71. The method according to claim 70, wherein the patterning is carried out with use of a nanoscopic tip.

72. The method according to claim 70, wherein the tip is an atomic force microscopic tip.

73. The method according to claim 70, wherein the precursor is a sol gel precursor.

74. The method according to claim 70, wherein the magnetic solid state material is a hard magnetic solid state material.

75. The method according to claim 70, wherein the magnetic solid state material is a soft magnetic solid state material.

76. A magnetic nanostructure comprising a substrate and one or more magnetic nanostructures disposed thereon, wherein the nanostructure has a lateral area of about 100,000 nm^2 or less.

77. The magnetic nanostructure according to claim 76, wherein the nanostructure has a lateral area of about 10,000 nm^2 or less.

78. The magnetic nanostructure according to claim 76, wherein the nanostructure has a lateral area of about 1,000 nm^2 or less.

79. The magnetic nanostructure according to claim 76, wherein the nanostructure has a height of about 50 nm or less.

80. The magnetic nanostructure according to claim 76, wherein the nanostructure is a hard magnetic nanostructure.

81. The magnetic nanostructure according to claim 76, wherein the nanostructure is a soft magnetic nanostructure.

82. The magnetic nanostructure according to claim 76, wherein the nanostructure is a sol-gel magnetic nanostructure.

83. The magnetic nanostructure according to claim 76, wherein the nanostructure is a hard, sol-gel magnetic nanostructure.

84. The magnetic nanostructure according to claim 76, wherein the nanostructure is a dot have an area of about 10,000 to about 30,000 square nanometers.

85. The magnetic nanostructure according to claim 76, wherein the nanostructure has a lateral area of 100,000 nm^2 or less and is disposed on the substrate with sufficient stability to be stable to solvent washing.

86. The magnetic nanostructure according to claim 76, wherein the nanostructure has a lateral area of 10,000 nm^2 or less, and comprises a hard magnet.

87. The magnetic nanostructure according to claim 76, wherein the nanostructure has a lateral area of 1,000 nm^2 or less, is ferromagnetic, and the number of domains in the nanostructure is 10 or less.

88. The magnetic nanostructure according to claim 76, wherein the nanostructure has a lateral area of 100 nm^2 or less and a height of the nanostructure is about 5 nm to about 25 nm.

89. The magnetic nanostructure according to claim 76, wherein the nanostructure has a size dimension other than height of about one micron or less, and wherein the nanostructure is barrium ferrite.

90. The magnetic nanostructure according to claim 76, wherein the nanostructure has a size dimension other than height of about 100 nm or less, the nanostructure is a hard magnet, and wherein the height of the nanostructure is about 5 nm to about 25 nm..

91. An array of individual magnetic nanostructures comprising: a substrate and individual magnetic nanostructures disposed thereon, wherein the nanostructures have a lateral area of about 100,000 nm^2 or less.

92. The array according to claim 91, wherein the individual nanostructures are separated from each other by distances less than about one micron.

93. The array according to claim 91, wherein the individual nanostructures are separated from each other by distances less than about 500 nm.

94. The array according to claim 91, wherein the individual nanostructures are separated from each other by distances less than about 100 nm.

95. The array according to claim 91, wherein the array has a pattern density of one nanostructure per 5 X 10^6 nm^2 of substrate area or less.

96. The array according to claim 91, wherein the array has a pattern density of one nanostructure per 5 X 10^4 nm^2 of substrate area or less.

97. The array according to claim 91, wherein the array has a pattern density of one nanostructure per 5 X 10^2 nm^2 of substrate area or less, and the nanostructure height is about 5 nm to about 25 nm.

98. The array according to claim 91, wherein the nanostructures comprise hard magnets.

99. The array according to claim 91, wherein the nanostructures comprise soft magnets.

100. The array according to claim 91, wherein the nanostructures comprise ferromagnets.

101. The array according to claim 91, wherein the nanostructures comprise BaFe.

102. The array of claim 91, wherein the array comprises individual dots separated by a distance of less than about 500 nm from the dot centers and the dot diameters are less than about 500 nm.